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INTERNATIONAL WELFARE AND EMPLOYMENT LINKAGES ARISING FROM MINIMUM WAGES*

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We formulate a two-country model with monopolistic competition and heterogeneous firms to reconsider labor market linkages in open economies. Labor market imperfections arise by virtue of country-specific real minimum wages. Abstracting from selection of just the best firms into export status, standard effects on marginal and average firm productivity are reversed in our model, yet there are significant gains from trade arising from employment expansion. In addition, we show that with firm heterogeneity an increase in one country's minimum wage triggers firm exit in both countries and thus harms workers at home and abroad.

1. INTRODUCTION

The debate about the role of labor market institutions for labor market outcome is as vivid today as it was decades ago. This is true for academics as well as the political arena. Although the respective discussions are mostly concerned with the consequences of domestic labor market institutions for domestic workers, previous research clearly suggests that foreign labor market institutions also matter for domestic workers in an open economy. Based on insights from the seminal work of Davis (1998), it has become conventional wisdom in the scientific community that bad foreign labor market institutions exert a positive spillover on domestic workers, so that countries like the United States benefit from high European minimum wages.[2] Although such a positive spillover from foreign labor market frictions on domestic workers seems to be intuitive at a first glance, there is little empirical support for it. On the contrary, recent findings suggest that labor market outcomes at home and abroad are positively correlated and that domestic workers bear part of the burden of bad foreign labor market institutions (see Felbermayr et al., 2009).

It is the aim of this article to shed new light on this issue from a theoretical perspective and to provide a better understanding of the implications of bad labor market institutions for domestic and foreign workers. For this purpose, we set up an analytically tractable theoretical model that allows us to account for the role of labor market institutions on domestic and foreign workers in an open economy. The model, while in the interest of analytical tractability still relying on minimum wages as the source of labor market imperfection, differs in several important ways from Davis (1998) and the succeeding literature. Because our focus is on the international transmission of the consequences of labor market institutions between developed countries, we abstract from Heckscher–Ohlin-type reasons for trade but use a two-country new trade

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[2] In this respect, Davis' conclusion qualifies Krugman's (1994) "two-sides-of-the-same-medal" hypothesis, which relates labor market outcomes exclusively to domestic institutional settings, thereby ignoring international linkages due to trade relationships.

theory framework with a single factor of production (labor).[3] Furthermore, we allow for firm heterogeneity along the lines of Melitz (2003), so that producers differ in their productivity levels. In this setting, potentially asymmetric minimum wages between countries can be binding in both economies. Hence, our model features unemployment in both countries even though these countries differ in their institutional settings. This allows us to capture the well-established fact that workers on both sides of the Atlantic have a positive probability of being unemployed and are concerned about negative employment effects of trade (Nickell, 1997; Scheve and Slaughter, 2001; Davidson et al., 2012). This provides a suitable framework for studying the main question of interest in this article, namely, how do changes in foreign minimum wages affect domestic employment and welfare and vice versa?

After setting up the theoretical framework and studying the properties of the model under autarky, we analyze the impact of the economies' opening up to trade on a country with labor market frictions. In this respect, our analysis indicates that trade reduces the efficiency costs of a binding minimum wage, and hence generates gains in terms of both employment and welfare. These positive effects materialize irrespective of how large the differences in minimum wages are between the two countries. Furthermore, the employment stimulus in this model refers to an additional channel through which gains from trade can materialize, and our analysis shows that the increase in aggregate employment may generate positive welfare effects even if trade does not lead to an aggregate productivity gain as in Melitz (2003). In the open economy, we study the consequences of an increase in one country's minimum wage on employment and welfare. In our model, such a reform exerts a negative effect on both domestic and foreign workers. In contrast to Davis (1998), there is hence a negative spillover of stronger labor market institutions, indicating that European minimum wages prop up U.S. unemployment. In a final step of our analysis, we extend our model to one with international offshoring in order to understand how recent trends in globalization affect the main results from our analysis.

Studying involuntary unemployment in open economies, our article contributes to a relatively large literature that started more than three decades ago with the seminal work of Brecher (1974). In the first two decades, this literature was primarily concerned with employment effects of trade liberalization under different trade settings and various sources of labor market imperfection (see, e.g., Davidson et al., 1991; Matusz, 1996). However, this early literature did not address labor market linkages in open economies. This issue was first targeted by Davis (1998). In subsequent years, several authors have worked on improving our understanding about these linkages. Notable examples include Oslington (2002), Kreickemeier and Nelson (2006), and Meckl (2006). These studies were concerned with relaxing two restrictive properties of Davis' model: the existence of involuntary unemployment in just one country and, related to this point, the somewhat unrealistic feature that the country with the more flexible labor market is shielded from any external shock by the minimum wage of the other economy. However, none of these studies addressed Davis' (1998) finding of a positive spillover of higher European minimum wages on the U.S. labor market, which is in the limelight of this article's interest.

Aside from a large number of studies that address the impact of trade on imperfectly competitive labor markets in models with homogeneous producers, there is a growing literature that looks, as we do, at the interaction of firm heterogeneity and labor market institutions in the process of globalization. Existing studies to this literature build on sophisticated models of labor market imperfection, like efficiency wages (see Davis and Harrigan, 2011; Egger and Kreickemeier, 2009; Amiti and Davis, 2011), search frictions (see Davidson et al., 2008; Helpman and Itskhoki, 2010; Helpman et al., 2010; Felbermayr et al., 2011), or unions (see Eckel and Egger, 2009), in order to improve our understanding upon how firm-specific effects of trade affect individual workers. However, due to the complexity of the labor market side of the models, the formal analysis in these studies is usually confined to symmetric countries, rendering a detailed discussion of labor market linkages impossible. Two notable exceptions are Felbermayr et al.

[3] The assumption of a single factor is innocent in our context but helps keep the analysis tractable.

(2009), who set up a search and matching model to derive—by virtue of simulations only—a reduced-form spatial econometric model of domestic and foreign unemployment rates, and Helpman and Itskhoki (2010), who show in a simulation exercise that stronger labor market frictions in one country exhibit negative effects on the unemployment rate of a trading partner. However, contrary to our study these contributions neither determine the labor market linkages analytically nor do they discuss in detail how these linkages are related to the assumption of firm heterogeneity.

The impact of offshoring on domestic labor market outcomes, which we address in an extension to our baseline model, has been studied in several papers, most of them considering a partial equilibrium environment (see, for instance, Skaksen and Sørensen, 2001; Lommerud et al., 2003, 2009). Aggregate employment effects of offshoring in a general equilibrium setting are discussed in Egger and Egger (2003) and Egger and Kreickemeier (2008). However, these studies do not look at the consequences of offshoring for international labor market linkages. The latter issue has been tackled by Ethier (2005). He considers a traditional two-country, two-sector, two-factor trade model with offshoring from industrialized to less-advanced countries in order to show that trade in intermediate goods may be the reason for the empirical finding of a comovement in the skill premium of developed and developing countries over the last few decades. With a focus on cross-country linkages in *relative wages* rather than in *relative employment*, the findings in Ethier (2005) are complementary to ours.

The remainder of the article is organized as follows. In Section 2, we briefly describe our modeling strategy and discuss how and to what extent the main model assumptions govern our results. In Section 3, we set up the basic model structure and investigate the autarky equilibrium. In Section 4, we characterize the equilibrium of the open economy and compare the respective outcome with the autarky scenario. Section 5 provides a comparative static analysis to study the impact that an increase in the European minimum wage exhibits on employment and aggregate wage income in Europe and the United States. In Section 6, we allow for international offshoring within multinational firms, in order to see whether and to what extent the insights from our analysis depend on the mode of firm organization. The last section concludes with a brief summary of the most important results.

2. AN INFORMAL ACCOUNT OF THE ANALYSIS

To conduct our analysis, we set up a model in which firms produce and supply differentiated intermediate goods under monopolistic competition as in Ethier (1982) and Markusen (1989). Intermediate goods production uses labor as the only input and intermediates are aggregated into a homogeneous output good. As is well known from these models, opening up an economy provides access to a larger pool of intermediate varieties and, hence, creates gains from trade through a positive external scale effect (that can be associated with amplified division of labor). Following Melitz (2003), we assume that producers in the differentiated goods industry are heterogeneous with respect to their productivity. As compared to a framework with homogeneous firms, the assumption of heterogeneous producers opens an additional channel through which countries can benefit from trade liberalization: changes in the composition of producers due to exit of the least productive competitors and self-selection of productive firms into export status.

Although either effect is crucial for the welfare implications of trade liberalization, it is the adjustment at the extensive margin of firms (i.e., exit from/entry into the market as such) that is essential for our analysis. It is thus convenient to focus on compositional effects at the extensive margin, while disregarding selection into export status by setting trade costs equal to zero. Furthermore, we restrict our attention to trade between two economies, which are identical in all respects except of their labor market institutions. Labor market institutions are introduced by means of a real minimum wage, which may differ between the two economies. If the real minimum wage, that is, the nominal wage divided by the consumer price index, is binding, production faces a perfectly elastic labor supply as opposed to perfectly inelastic labor supply in the Ethier as well as the Melitz model. Clearly, with a binding real minimum wage, there exists a third channel through which countries can benefit from trade liberalization: an increase in the employment rate. As pointed out in our analysis, this employment effect is closely related to and interacts with the other two sources of gains from trade.

Regarding the existence of cross-country spillovers of national labor market institutions, it is notable that international trade links the variable production costs of intermediate goods producers at home and abroad. In a Krugman (1980)-type model with homogeneous producers (under diversified production and free trade), the minimum wage could only be binding in one country while full employment prevails in the other one. The reason is that if one of the two economies (say Europe) faced a higher minimum wage than the other economy (say, the United States), intermediate goods producers in Europe would be forced to exit, while at the same time new intermediate goods producers would enter in the United States. Intuitively, production shifts to the country that offers lower production costs. This adjustment process would continue until all workers in the United States were employed and U.S. wages were driven up to the European minimum wage. As in Davis (1998), an increase in the binding real minimum wage would therefore raise unemployment in Europe and prop up wages in the United States if firms were homogeneous.

However, if firms differ in their production costs due to heterogeneity in productivity, trade only equalizes the variable production costs of the *marginal* (i.e., the least productive) producers in the two economies. In this case, minimum wages can differ and still be binding in both countries as long as productivity differences of marginal firms compensate for the prevailing wage differences. As a consequence, country-specific minimum wages may lead to involuntary unemployment in both economies if firms differ in their productivity levels. Notably, if Europe raises its minimum wage, U.S. workers need not benefit from it. The reason is that there are two counteracting effects. On the one hand, a higher minimum wage induces an efficiency loss and hence reduces aggregate world demand for intermediate goods. This hurts both economies and hence forces firms to exit in Europe and the United States ceteris paribus. On the other hand, there is a relocation of production of intermediate goods from Europe to the United States in response to a relative rise of the European minimum wage. Whereas both of these effects also exist in a model with homogeneous firms, the second effect is dampened with heterogeneous producers due to a decline of the marginal U.S. firm's productivity (triggered by entry of new firms with low productivity) and an increase of the marginal European firm's productivity (triggered by exit of the least productive incumbent firms). As a consequence, the second (production relocation) effect does not necessarily compensate the first (aggregate demand) effect so that a higher European minimum wage may lower employment in Europe as well as the United States. This indicates that negative spillover effects of an increase in labor market imperfections are possible in open economies if firms differ in their productivity levels and, hence, provides an intuition for the negative spillover of bad labor market institutions on employment in the trading partner, as documented by Felbermayr et al. (2009).

3. THE CLOSED ECONOMY

3.1. *Basic Model Assumptions.* We consider a model with one homogeneous final good—used for consumption as well as investment—and a mass of differentiated intermediate goods. The economy under consideration is populated by L workers, each supplying one unit of labor. The production technology in the final goods sector is CES and represented by

$$Y = M^{-\frac{\eta}{\sigma-1}} \left(\int_{v \in V} q(v)^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $q(v)$ is the quantity of intermediate variant v employed in the production of Y, V is the set of available varieties with measure M, and σ denotes the elasticity of substitution between variants of the intermediate. Parameter $\eta \in [0, 1]$ is inversely related to the standard Dixit–

Stiglitz variety effect, which we will refer to as the "external scale effect," following Ethier (1982). In the borderline case of $\eta = 1$, the variety or external-scale effect vanishes, and Y has constant-returns to scale in both the levels and the number of varieties. In the case of $\eta = 0$, we have the standard Dixit–Stiglitz case, where Y exhibits increasing returns and is homogeneous of degree $\sigma/(\sigma - 1)$ in the measure of varieties. The special cases of (i) $\eta = 0$ and (ii) $\eta = 1$ are respectively given by

$$(1') \qquad Y = \left(\int_{v\in V} q(v)^{\frac{\sigma-1}{\sigma}} dv\right)^{\frac{\sigma}{\sigma-1}}, \qquad Y = M^{\frac{1}{1-\sigma}} \left(\int_{v\in V} q(v)^{\frac{\sigma-1}{\sigma}} dv\right)^{\frac{\sigma}{\sigma-1}}.$$

As will be discussed in detail in Subsection 3.3, a necessary (but not sufficient) condition for Walrasian stability of the equilibrium in the presence of minimum wages is that $\eta > 0$.

Let us use P to denote the price of the homogeneous final good and $p(v)$ to denote the price of intermediate variant v. Final goods producers choose $q(v)$ (for all v) in order to maximize their profits, $PY - \int_{v\in V} p(v)q(v)dv$. Under perfect competition, the price of each intermediate good equals this good's marginal revenue product and profits of final goods producers are driven down to zero due to free market entry. Consequently, P must fulfill the zero profit condition $PY = \int_{v\in V} p(v)q(v)dv$, and hence it is given by a CES index of intermediate goods prices $P = [M^{-\eta}\int_{v\in V} p(v)^{1-\sigma}dv]^{1/(1-\sigma)}$. Choosing final output as the numéraire and setting its price equal to unity, we can formulate the solution to the profit maximization problem of final goods producers in the following way:

$$(2) \qquad q(v) = \frac{Y}{M^{\eta}} p(v)^{-\sigma},$$

with the latter characterizing demand for intermediate good variety v.

Intermediate goods are supplied by monopolistically competitive firms, with each firm producing a unique variety (and thus M being equal to the mass of competitors). Output of an intermediate goods producer depends on labor input l and labor productivity ϕ: $q = \phi l$. Marginal production costs are given by w/ϕ, with w denoting a (real) minimum wage that is identical across firms and set by the government. Facing demand (2) and taking aggregate variables as given, intermediate goods producers maximize their profits by setting prices as a constant markup over marginal costs. This yields

$$(3) \qquad p(\phi) = \frac{\sigma w}{(\sigma - 1)\phi}$$

and concludes our brief discussion on profit maximization of intermediate goods producers, when taking their entry decision as given.

3.2. *Firm Entry and Aggregation.* Regarding firm entry, we apply a modified version of the Melitz (2003) framework and assume that the mass of potential entrants is exogenously given by parameter N. These potential entrants differ in their productivity levels ϕ, with $G(\phi)$ denoting the cumulative distribution of productivity. Hence, entry reduces to a one-stage process and we obtain a static model with aggregate profits being strictly positive (see Chaney, 2008; Do and Levchenko, 2009). In all other respects, the properties of the goods market variables in the static model variant are the same as those of the dynamic version in Melitz (2003).

In particular, for given aggregate variables, productivity of the marginal active firm—which exhibits the lowest productivity level that is consistent with nonnegative profits—is determined by a zero cutoff profit condition. Assuming that the operation of an input firm requires the initial investment of *one* unit of final output Y, the respective condition reads[4]

$$r(\phi^*) = \sigma, \tag{4}$$

where ϕ^* denotes the productivity level of the marginal firm (in short, *cutoff productivity*) and $r(\phi^*) = (Y/M^\eta)p(\phi^*)^{1-\sigma}$ denotes revenues of this firm. Hence, the mass of active firms is determined as $M = N(1 - G(\phi^*))$. In order to obtain aggregate variables, we can characterize an average firm by the following condition: $P = M^{(1-\eta)/(1-\sigma)}p(\tilde{\phi})$. As discussed in Melitz (2003), the productivity level of the average firm (*average productivity*, in short), $\tilde{\phi}$, equals the weighted harmonic mean of the productivity levels of active producers, with relative outputs $q(\phi)/q(\tilde{\phi})$ serving as weights. The usefulness of this productivity average flows from the observation that aggregate revenues, R, and aggregate profits, Π, are the same in our model as they would be if the economy were populated by M firms with identical productivity level $\tilde{\phi}$: $R = Mr(\tilde{\phi})$ and $\Pi = M\pi(\tilde{\phi})$, with $\pi(\tilde{\phi}) = r(\tilde{\phi})/\sigma - 1$. Final output is given by $Y = M^{(\sigma-\eta)/(\sigma-1)}q(\tilde{\phi})$, implying that $Y = M^{\sigma/(\sigma-1)}q(\tilde{\phi})$, if $\eta = 0$, and $Y = Mq(\tilde{\phi})$, if $\eta = 1$.

To facilitate our analysis, we impose the by now standard assumption of Pareto-distributed productivity levels and consider $G(\phi) = 1 - \phi^{-k}$, where k is the shape parameter of the Pareto distribution and the lower bound to productivity levels is normalized to unity (i.e., $\phi \geq 1$). The corresponding density function is given by $g(\phi) = k\phi^{-k-1}$.[5] Under the Pareto assumption, average productivity ($\tilde{\phi}$) is proportional to cutoff productivity (ϕ^*):

$$\tilde{\phi} = \left(\frac{k}{k - \sigma + 1}\right)^{\frac{1}{\sigma-1}} \phi^*, \tag{5}$$

where $k > \sigma - 1$ is assumed in order to ensure that the productivity average has a finite positive value (see Baldwin, 2005). Furthermore, revenues of the average firm are proportional to revenues of the marginal firm, and they are constant:

$$r(\tilde{\phi}) = \left(\frac{\tilde{\phi}}{\phi^*}\right)^{\sigma-1} r(\phi^*) = \frac{k\sigma}{k - \sigma + 1}. \tag{6}$$

3.3. *Equilibrium in the Closed Economy.* In order to characterize the autarky equilibrium, let us first concentrate on productivity levels ϕ^*, $\tilde{\phi}$, and the mass of firms M. Equilibrium values of these variables are determined by the following three equations. The first one is the *cutoff productivity condition* (CPC), which determines a relationship between the mass of competitors M and cutoff productivity ϕ^*: $M = N(1 - G(\phi^*)) = N(\phi^*)^{-k}$. The second one is the *average productivity condition* (APC), which links cutoff and average productivity, according to (5). The third one can be deduced from profit-maximizing behavior of firms and characterizes those combinations of cutoff productivity ϕ^* and the mass of competitors M that are consistent with this behavior. This *profit maximization condition* (PMC) can be determined by linking $r(\tilde{\phi}) = (Y/M^\eta)p(\tilde{\phi})^{1-\sigma}$ and $Y = Mr(\tilde{\phi})$ (which gives $p(\tilde{\phi}) = M^{(1-\eta)/(\sigma-1)}$) with (3), (5)

$$\frac{w\sigma}{\sigma - 1}\left(\frac{k}{k - \sigma + 1}\right)^{\frac{1}{1-\sigma}} \frac{1}{\phi^*} = M^{\frac{1-\eta}{\sigma-1}}. \tag{7}$$

[4] Notably, assuming that fixed costs are equal to unity is not essential for the results of interest here. It simply helps economize on notation.

[5] Besides its attractiveness in terms of analytical tractability, the Pareto assumption entertains considerable empirical support. For instance, Del Gatto et al. (2006, p. 17) conclude from a firm-level analysis in European industries that "Pareto is a fairly good approximation of the underlying productivity distributions."

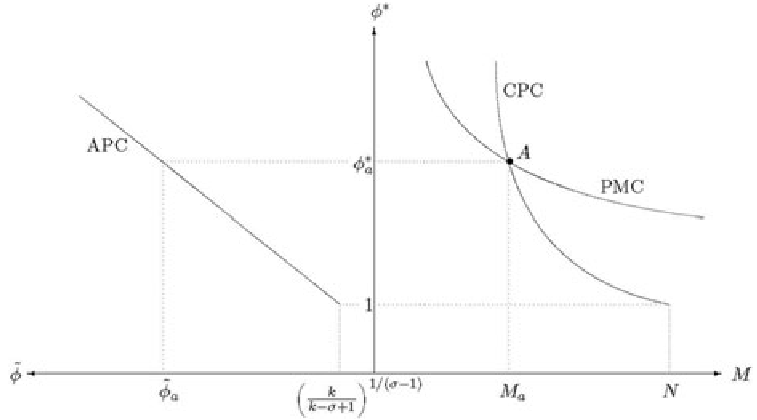

FIGURE 1

EQUILIBRIUM IN THE CLOSED ECONOMY

Figure 1 illustrates the three conditions and the equilibrium values of ϕ^*, $\tilde{\phi}$, and M graphically. (We use subscript a to refer to *autarky*, there.) For drawing the two loci in the right panel of this figure, we have imposed two additional assumptions. First, we assume that N is sufficiently small in order to ensure an intersection of the two downward sloping curves at $\phi^* > 1$ in the right panel of Figure 1.[6] Otherwise, the equilibrium would be characterized by $M = N$ and $\phi^* = 1$, and hence all potential producers would be active, irrespective of their productivity levels. We exclude this case in order to make our results comparable to those in Melitz (2003), who considers an unbounded mass of potential entrants. Second, (Walrasian) stability of the equilibrium requires $k(1 - \eta) < (\sigma - 1)$. This ensures that the CPC locus intersects the PMC locus from above. The respective condition is fulfilled if the external scale effect is not too large, that is, η is sufficiently close to unity. For an intuition about the latter, note that a bigger mass of competitors exhibits two effects on firm entry. On the one hand, it raises final goods output, thereby increasing demand for intermediate goods and thus rendering firm entry more attractive. This provides a source of instability, as a larger number of firms stimulates subsequent entry. Notably, this (aggregate demand) effect is the stronger, the larger is the external scale effect. On the other hand, a bigger M implies more competition among intermediate goods producers for a given level of final goods output and, hence, a negative impact on demand for each variety. The latter stabilizes the equilibrium in the sense that an increase in the mass of competitors lowers the incentive for further firm entry. From Equation (2), we can deduce that the latter effect is relatively strong if the external scale effect is weak, and it dominates the positive aggregate demand effect if $\eta > (k - \sigma + 1)/k$.[7,8] Summing up, if the mass of potential

[6] To be more specific, $N < \{[w\sigma/(\sigma - 1)]^{\sigma-1}[k/(k - \sigma + 1)]^{-1}\}^{1/(1-\eta)}$ is a necessary and sufficient condition for an intersection of the two loci in the relevant domain.

[7] Two remarks are in order here. First, it is clear that either of these effects materializes in any monopolistic competition model. However, in other models there exists an additional stabilizing force by means of increasing factor prices in response to firm entry. This adjustment channel has been closed in our model by considering a binding real minimum wage that constrains the parameter domain supporting a stable equilibrium. Second, the minimum level of η that supports existence of a stable equilibrium increases in k. The reason is that a higher k lowers the elasticity of cutoff productivity ϕ^* with respect to M (in absolute terms). A given increase in M leads to a smaller reduction of ϕ^* (and, hence, $\tilde{\phi}$) at higher k, thereby aggravating the positive aggregate demand effect of a greater mass of M as described above. The latter amplifies the destabilizing forces in the model ceteris paribus and, hence, requires η to increase in order to support a stable equilibrium at higher k.

[8] At $\eta < (k - \sigma + 1)/k$, the CPC locus would cross the PMC locus from below, and intersection point A would no longer characterize a stable equilibrium. To see this, consider an increase in the mass of competitors starting from point A. This would reduce ϕ of the marginal producer, according to CPC. However, with $\eta < (k - \sigma + 1)/k$ (and thus PMC located above APC and to the right of A) the respective productivity level would be above the PMC locus, implying

entrants is sufficiently small and the external scale effect is not too strong, then a *unique* and *stable* autarky equilibrium exists. In the borderline case of no external scale effects, i.e., at $\eta = 1$, the PMC locus becomes horizontal and the existence of a stable equilibrium is guaranteed.[9]

A higher minimum wage, w, renders production of firms with low productivity levels unattractive and thus raises marginal productivity ϕ^* and, by virtue of (5), also average productivity $\tilde{\phi}$. At the same time, the mass of active firms declines because of the negative link between ϕ^* and M that follows from CPC. Graphically, an increase in the minimum wage shifts the PMC locus outwards, with the respective productivity and firm number effects following from Figure 1. A larger pool of potential entrants, N, shifts the CPC locus outwards with a positive effect on the mass of active firms M. If there are external scale effects, i.e., $\eta < 1$, the higher mass of active firms induces higher demand for all intermediate goods. As a consequence, market entry now becomes attractive for firms with relatively low productivity levels, implying that ϕ^* and $\tilde{\phi}$ decline. In the borderline case of $\eta = 1$, the increase in M does not stimulate demand for intermediate goods so that ϕ^* and $\tilde{\phi}$ remain unaffected by the increase in the mass of potential entrants, N.

To facilitate a comparison between autarky and the trade equilibrium in the next section, it is useful to explicitly solve for aggregate product market variables. Straightforward calculations yield

$$\phi_a^* = \left(\frac{\sigma-1}{w\sigma}\right)^{\frac{\sigma-1}{k(1-\eta)-\sigma+1}} \left(\frac{kN^{1-\eta}}{k-\sigma+1}\right)^{\frac{1}{k(1-\eta)-\sigma+1}}, \tag{8}$$

$$\tilde{\phi}_a = \left(\frac{\sigma-1}{w\sigma}\right)^{\frac{\sigma-1}{k(1-\eta)-\sigma+1}} \left[\left(\frac{k}{k-\sigma+1}\right)^{\frac{k}{\sigma-1}} N\right]^{\frac{1-\eta}{k(1-\eta)-\sigma+1}} \tag{9}$$

and

$$M_a = \left(\frac{w\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}}. \tag{10}$$

Total output of final goods can now be determined by combining the adding-up condition $Y = Mr(\tilde{\phi})$ with Equations (6) and (10). This yields

$$Y_a = \left(\frac{w\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \frac{k\sigma}{k-\sigma+1} \tag{11}$$

and completes our discussion of the goods market equilibrium in autarky.

For characterizing the labor market outcome, note that the constant markup-pricing rule establishes a proportional relationship between revenues $p(\phi)q(\phi)$ and labor cost expenditures $wl(\phi)$ at the firm level: $p(\phi)q(\phi) = wl(\phi)\sigma/(\sigma-1)$. Furthermore, let us denote the unemployment rate by u and employment of the average firm by $l(\tilde{\phi})$. Then, due to the adding-up condition, employment in all firms, $Ml(\tilde{\phi})$, must equal the total employed labor force, $(1-u)L$. Accordingly, total labor cost expenditures (which are equal to aggregate labor income, W) are proportional to total revenues, that is, $W = Mr(\tilde{\phi})[(\sigma-1)/\sigma]$, with $Mr(\tilde{\phi}) = Y$ and

that the marginal producer would realize positive profits, thereby rendering further firm entry attractive. Because, by a similar argument, a reduction of M would render further firm exit attractive, we can safely conclude that intersection point A would be inconsistent with a stable equilibrium if $\eta < (k-\sigma+1)$.

[9] It is notable that, in contrast to Melitz (2003), we did not make use of the zero cutoff profit condition in (4) and (6) for characterizing the equilibrium in Figure 1. However, this condition will play a role for determining equilibrium output and employment in autarky (see below).

$W \equiv (1-u)Lw$. Hence, the equilibrium values of aggregate labor income and unemployment are given by

$$W_a = \left(\frac{w\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \frac{k(\sigma-1)}{k-\sigma+1} \tag{12}$$

and

$$u_a = 1 - \left(\frac{w\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \frac{k(\sigma-1)}{Lw[k-\sigma+1]} \tag{13}$$

respectively, according to (11).

For the minimum wage to be binding, that is, for $u_a > 0$, the pool of workers L needs to be sufficiently large. This is assumed from now on. A higher L raises unemployment u and leaves aggregate wage income W unaffected. With constant markup pricing, aggregate wage income is proportional to total output of final goods, which has been shown to be independent of L. With a binding minimum wage, an increase in L reduces employment rate $(1-u)$ proportionally, thereby leaving aggregate employment unchanged. However, from this result it should not be deduced that the unemployment rate exhibits a country-size pattern. To the extent that larger economies also have a larger pool of potential entrants, N, the model is consistent with the empirical observation that unemployment may be a problem of large as well as small economies (see Chaney, 2008). Beyond that, a higher minimum wage lowers total labor income W and worsens the unemployment problem, if $k(1-\eta) < \sigma - 1$. This is intuitive, as a higher minimum wage reinforces the labor market imperfection and therefore renders the market outcome less efficient. This completes our discussion of the autarky equilibrium.

4. THE OPEN ECONOMY

We now assume that there are two countries whose economies are of the type described in the previous section. The two countries are fully identical except for the size of minimum wages. The minimum wage is binding in both economies and we associate the country with the higher minimum wage with Europe (superscript E) and the other one with the United States (superscript A) in order to capture the empirical fact that labor market imperfections are more severe in Europe than in the United States. Workers are immobile, and firms can serve the foreign market only through exports; the consequences of offshoring of production within vertical multinational firms are discussed in an extension to our model (see Section 6). Furthermore, to facilitate our analysis, we abstract from any trade impediments (for final goods as well as intermediates) and assume that all intermediate goods producers are exporters.[10] Accordingly, Y and P are identical for all firms, irrespective of the country in which they produce and, hence, the zero cutoff profit conditions, which are given by $r_E(\phi_E^*) = \sigma$ and $r_A(\phi_A^*) = \sigma$, respectively, result in

$$\frac{\phi_E^*}{\phi_A^*} = \frac{w_E}{w_A}, \tag{14}$$

which is strictly larger than unity, if $w_E > w_A$. Equations (3) and (14) imply $p_E(\phi_E^*) = p_A(\phi_A^*)$ as well as $p_E(\tilde{\phi}_E) = p_A(\tilde{\phi}_A)$, where $\tilde{\phi}_i$, $i = A, E$ is defined analogously to the closed economy case

[10] It is an empirical stylized fact that there is self-selection into export status and that exporters exhibit higher levels of productivity than nonexporters (see, e.g., Bernard and Jensen, 1995, 1999). However, accounting for exporting as well as nonexporting firms in the model would only complicate our analysis without changing the main insights.

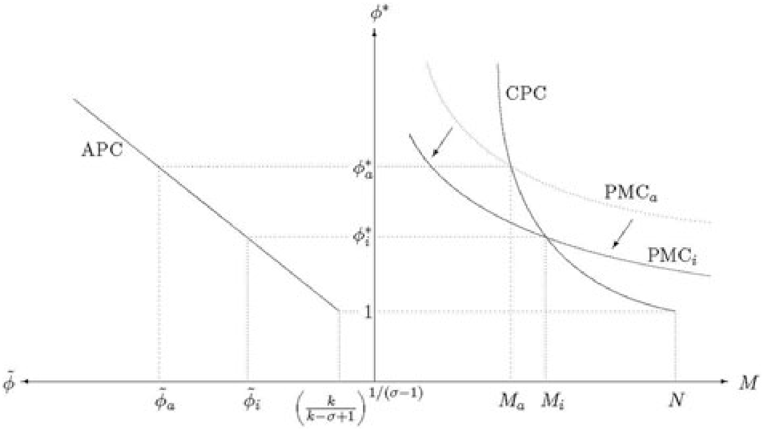

FIGURE 2

EQUILIBRIUM IN THE OPEN ECONOMY

and, hence, it is proportional to the cutoff productivity level, according to (5).[11] As noted in previous contributions on the matter, in the open economy it is necessary to distinguish between the average productivity of domestic firms, $\tilde{\phi}_i$, and the average productivity in the market, $\tilde{\phi}_{it}$, with the latter accounting for domestic production as well as the imports of foreign producers. This average market productivity is defined in a way to ensure that $P = M_t^{(1-\eta)/(1-\sigma)} p_i(\tilde{\phi}_{it})$ holds, with $M_t \equiv M_A + M_E$ denoting the total mass of intermediate goods available at the market. As extensively discussed in Egger and Kreickemeier (2009), the two averages $\tilde{\phi}_{it}$ and $\tilde{\phi}_i$ are identical only if the negative *lost-in-transit* effect (caused by goods melting away en route when international transactions are subject to iceberg transport costs) and the positive *export-selection* effect (caused by selection of only the firms with relatively high productivity levels into exports status) are of the same size. Because we abstract from any trade impediments and all firms export in this article, $\tilde{\phi}_{it} = \tilde{\phi}_i$ must hold.

With the characterization of the average firm at hand, we can now proceed to determine the goods market equilibrium in the open economy. For this purpose, we can again employ the CPC, the APC, and the PMC to solve for the equilibrium values of M_i, ϕ_i^*, and $\tilde{\phi}_i$. Whereas the CPC and APC conditions are the same as in the closed economy, the specification of PMC has to be adjusted, because in the open economy the mass of domestically produced intermediates is smaller than the total mass of available intermediates. By virtue of (14), we have $M_t = [1 + (w_i/w_j)^k]M_i$, $i \neq j$ and, hence, the country-specific PMC in the open world economy is given by

$$\frac{w_i \sigma}{\sigma - 1}\left(\frac{k}{k-\sigma+1}\right)^{\frac{1}{1-\sigma}} \frac{1}{\phi_i^*} = \left[\left(1 + \left(\frac{w_i}{w_j}\right)^k\right) M_i\right]^{\frac{1-\eta}{\sigma-1}}. \tag{15}$$

Figure 2 depicts the three conditions and the equilibrium values of M_i, ϕ_i^*, and $\tilde{\phi}_i$. To facilitate the comparison of the closed and the open economy cases, we also display the autarky equilibrium. From inspection of the figure it is immediate that a movement from autarky to free trade reduces the cutoff and average productivity levels, while it increases the mass of active intermediate goods producers with headquarters in country i.[12] This is in sharp contrast to the Melitz framework and, hence, calls for further discussion.

[11] With constant markup pricing, $p_E(\phi_E^*) = p_A(\phi_A^*)$ also implies that variable production costs of the two marginal firms are equalized in the open economy. This, however, is not true for the closed economy and, hence, the ratio of cutoff productivity levels does not equal the ratio of minimum wages under autarky; see Equations (8) and (14).

[12] The finding that the average productivity needs to fall when a country moves from autarky to trade is a consequence of abstracting from any transport costs, and hence from selection of just the best firms into export status. With

In Melitz' original framework, the most productive firms start exporting in the open economy and production expands at the intensive margin ceteris paribus. This raises nominal wages and, hence, forces the least productive nonexporters to exit. As a consequence, the mass of domestic producers shrinks and marginal productivity increases if a country opens up to trade. In our model, labor supply is perfectly elastic at the mandated real minimum wage and, hence, the nominal wage rate is uncoupled from changes in labor demand. An increased mass of available intermediate varieties M in the open economy leads to a fall in the price index (if $\eta < 1$) and, due to a constant real minimum wage, provokes a decline in the nominal wage rate. This allows less productive firms to enter in the open economy and induces a decline in the cutoff productivity level when a country opens up to trade.[13]

Using the three conditions CPC, APC, and PMC$_i$, we can explicitly solve for the equilibrium values of ϕ^*, $\tilde{\phi}$, and M in the open economy. This gives

$$\phi_i^* = \left(\frac{\sigma-1}{w_i\sigma}\right)^{\frac{\sigma-1}{k(1-\eta)-\sigma+1}} \left(\frac{kN^{1-\eta}}{k-\sigma+1}\right)^{\frac{1}{k(1-\eta)-\sigma+1}} \left[1+\left(\frac{w_i}{w_j}\right)^k\right]^{\frac{1-\eta}{k(1-\eta)-\sigma+1}}, \tag{16}$$

$$\tilde{\phi}_i = \left(\frac{\sigma-1}{w_i\sigma}\right)^{\frac{\sigma-1}{k(1-\eta)-\sigma+1}} \left[\left(\frac{k}{k-\sigma+1}\right)^{\frac{k}{\sigma-1}} N\right]^{\frac{1-\eta}{k(1-\eta)-\sigma+1}} \left[1+\left(\frac{w_i}{w_j}\right)^k\right]^{\frac{1-\eta}{k(1-\eta)-\sigma+1}} \tag{17}$$

and

$$M_i = \left(\frac{w_i\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \left[1+\left(\frac{w_i}{w_j}\right)^k\right]^{\frac{k(1-\eta)}{\sigma-1-k(1-\eta)}}. \tag{18}$$

Furthermore, noting that revenues of the average firms in A and E do not differ and that these revenues are the same in the open and the closed economy cases, output of final goods can easily be determined by multiplying the right-hand side of (6) by M_i. By virtue of (18), we obtain

$$Y_i = \left(\frac{w_i\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \frac{k\sigma}{k-\sigma+1} \left[1+\left(\frac{w_i}{w_j}\right)^k\right]^{\frac{k(1-\eta)}{\sigma-1-k(1-\eta)}}, \tag{19}$$

which is larger than the respective output level in autarky (see (11)), provided that $k(1-\eta) < \sigma - 1$. Because output increases in both economies, it is immediate that worldwide final goods production must also be higher in the open than in the closed world economy.

With these insights at hand, we can now pursue the analysis in the closed economy step by step to determine aggregate labor income, $W_i = (1-u_i)Lw_i$, and the unemployment rate, u_i. In particular, we can make use of the insight that constant markup pricing gives rise to $(1-u_i)L_iw_i = [(\sigma-1)/\sigma]M_ir_i(\tilde{\phi}_i)$, in order to solve explicitly for the two variables of interest. Straightforward calculations yield

$$W_i = \left(\frac{w_i\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \frac{k(\sigma-1)}{k-\sigma+1} \left[1+\left(\frac{w_i}{w_j}\right)^k\right]^{\frac{k(1-\eta)}{\sigma-1-k(1-\eta)}} \tag{20}$$

partitioning of firms by their export status, average productivity in the open economy would be stimulated and possibly higher than the respective value under autarky.

[13] In the borderline case of $\eta = 1$, the higher mass of active firms in the open economy does not affect the price index so that the nominal wage rate stays constant. As a consequence, the mass of local producers does not change in response to trade liberalization.

and

$$(21)\quad u_i = 1 - \left(\frac{w_i\sigma}{\sigma-1}\right)^{\frac{k(\sigma-1)}{k(1-\eta)-\sigma+1}} \left(\frac{k-\sigma+1}{kN^{(\sigma-1)/k}}\right)^{\frac{k}{k(1-\eta)-\sigma+1}} \frac{k(\sigma-1)}{Lw_i[k-\sigma+1]}\left[1+\left(\frac{w_i}{w_j}\right)^k\right]^{\frac{k(1-\eta)}{\sigma-1-k(1-\eta)}}.$$

Because revenues of the average firm do not change when a country moves from autarky to trade, it follows from Figure 2 that aggregate labor income rises due to the increase in the mass of local producers M_i. Furthermore, with the minimum wage being binding in the closed as well as the open economy, the increase in aggregate labor income must be accompanied by a fall in the unemployment rate. These positive labor market implications are well in line with the finding for the competitive labor market model in Melitz (2003), where a movement from autarky to trade raises the demand for labor and thus leads to higher real wages. Furthermore, a positive employment effect of trade is also well in line with recent findings in the literature on heterogeneous firms and labor market imperfection due to search frictions. For instance, in a setting with symmetric countries, Felbermayr et al. (2011) identify such a positive employment effect under mild parameter restrictions.[14] However, in their framework, part of the positive labor market effects are absorbed by an increase in the real wage and, hence, the employment stimulus is less pronounced, ceteris paribus, than in our setting, where the real wage stays constant by assumption.

One further remark is in order here. Although the focus of our analysis is on the labor market effects of trade liberalization, it is nonetheless possible (and probably interesting) to derive the respective welfare implications. Because there is only one final good in our model, total income I_i can be used as a suitable utilitarian welfare measure for country $i = A, E$. I_i is given by the sum of aggregate labor income, $W_i = [(\sigma-1)/\sigma]M_i r_i(\tilde{\phi}_i)$, and aggregate profits of domestic firms at unitary fixed costs, $\Pi_i \equiv M_i[r_i(\tilde{\phi})/\sigma - 1]$. With $r_i(\tilde{\phi})$ being constant according to (6), it follows directly that total income I_i is proportional to M_i and thus higher in the open than the closed economy. Hence, there are gains from trade in our setting. Although the existence of welfare gains in a heterogeneous firms model is not new, it is notable that the source of these gains differs conceptually from those in Melitz (2003), where the increase in productivity levels is a key source of gains from trade. In our model, both the cutoff and the average productivity levels decline, if a country opens up to trade. However, aggregate employment expands due to entry of less productive firms (and a larger scale of incumbent producers), thereby reducing the negative consequences of labor market imperfection.[15]

5. MINIMUM WAGES IN THE OPEN ECONOMY

In the previous section, we have characterized the equilibrium in the open economy for two countries that differ in their minimum wages. Furthermore, we have seen that, irrespective of the level of minimum wages, both countries benefit from the opening up to trade. However, the analysis so far has not provided any insights on how variations in one country's minimum wage affect the other economy. These cross-country linkages are at the heart of interest in the subsequent comparative-static analysis.

Our starting point is an equilibrium in the open economy as characterized in Section 4. Now hypothesize that Europe raises its minimum wage from w_E^0 to w_E^1. Similar to the closed economy

[14] In Helpman and Itskhoki (2010) trade does not influence labor market tightness and thus the unemployment rate at the sector level. However, in their two sector-model, economy-wide employment may either increase or decrease due to the cross-sectoral relocation of workers in response to trade (see Helpman et al., 2010, for further discussion).

[15] Clearly, aside from the productivity and the employment effects, there are also welfare gains due to the access to foreign intermediates and hence a stronger division of labor in the open economy. As it is well established in new trade theory, such welfare gains depend crucially on the existence of external scale effects (see Ethier, 1982; Markusen, 1989). However, external scale effects are also elementary for welfare gains through positive employment effects, which can only materialize if the mass of local firms increases (see the above discussion).

case, this shifts the European PMC locus outwards in Figure 2 and thus induces exit of local producers, that is, M_E declines. The intuition behind this effect is that an increase in the minimum wage reduces revenues of European firms, thereby rendering it unattractive for the marginal producer in the benchmark equilibrium to stay active. At the same time, ϕ_E^* and $\tilde{\phi}_E$ increase—as they are linked to M_E through CPC and APC. Although these effects are well understood from the closed economy case, there is a crucial difference between the two scenarios. A fall in M_E reduces the overall mass of available intermediate varieties M_t in the open economy, with negative consequences for the United States if external scale effects are in play, that is, if $\eta < 1$.

With external scale effects, a reduction in the mass of available intermediate varieties in Europe lowers demand for varieties produced in the United States. Hence, the higher minimum wage in Europe triggers exit of the least productive firms and thus leads to higher cutoff and average productivity levels in the United States; see (15). Graphically, the increase in w_E shifts the PMC$_A$ locus outwards with positive effects on ϕ_A^* and $\tilde{\phi}_A$ and a negative impact on M_A. The latter is an immediate implication of firm heterogeneity, which dampens firm exit in Europe as well as firm entry in the United States. Due to this, the negative efficiency effect of a higher European minimum wage dominates the positive relocation effect, implying that the mass of U.S. producers declines on net. Furthermore, because both the employment rate $1 - u_i$ and aggregate wage income W_i are proportional to the mass of local producers, it is immediate that a higher minimum wage in Europe harms U.S. workers. Put differently, Europe can *export* part of the costs of a higher minimum wage to the U.S. labor market in the open world economy. This differs from the respective conclusion of the analysis in Davis (1998) but motivates a negative spillover of bad labor market institutions on employment in the trading partner as well documented by Felbermayr et al. (2009).

6. LABOR MARKET LINKAGES UNDER OFFSHORING OF INTERMEDIATE GOODS PRODUCTION

In the previous analysis, intermediate goods were tradable but it was not possible for firm owners in one country to offshore their production to the other economy if it was cheaper to do so. In this section, we relax this assumption and study the incentives of firms in the more constrained labor market (referred to as Europe, E) to offshore their production of intermediate goods within a multinational organization to the relatively less constrained labor market (referred to as the United States, A) without changing the country headquarters are located in. Hence, profits accrue to the same country with offshoring as with integrated home production. The concept and incentive of offshoring in this model is similar to the one of unbundling of production in models with vertical multinational enterprises (see Helpman, 1984; Markusen, 2002), except that firms are heterogeneous here and offshoring requires producing with the firm-specific technology abroad.

Clearly, if there were no costs to offshoring, firms would always produce in the country with lower wages. As a consequence, only one country's minimum wage could be binding and labor market linkages would be the same as in a model with homogeneous firms. In this case, an increase in the minimum wage of Europe would prop up U.S. wages, similar to Davis (1998). So, let us generally focus on the case where offshoring invokes an investment of f units of final output in order to establish a production facility abroad. It is convenient (yet not crucial for our results) to assume that $f = 1$ in order to keep notation simple. In this case, firms that shift production have to pay twice the fixed costs of exporters.

Let us consider a minimum wage differential that is sufficiently small to ensure that not all European firms engage in offshoring. Then, the marginal producers in the two countries are exporters, and revenues of the marginal firms do not differ from those in the *pure exporter* scenario discussed in Sections 4 and 5. Hence, productivity levels of the marginal producers in the two economies are linked to the minimum wage ratio according to (14), provided that the minimum wage remains binding in both economies, which is assumed throughout the subsequent analysis. Furthermore, the marginal offshoring firm in the high-minimum-wage country (indicated by superscript o) is characterized by the indifference condition, $r_A(\phi_E^o)/\sigma - 1 = r_E(\phi_E^o)/\sigma$, which, accounting for $r_A(\phi) = (w_E/w_A)^{\sigma-1} r_E(\phi)$, can be explicitly solved for $r_E(\phi_E^o)$. Combining the resulting expression with the zero cutoff profit condition for country E and denoting the share of offshoring firms by $\chi \equiv (\phi_E^o/\phi_E^*)^{-k}$, we obtain

$$\chi = \left[\left(\frac{w_E}{w_A}\right)^{\sigma-1} - 1\right]^{\frac{k}{\sigma-1}}. \tag{22}$$

Intuitively, the share of European offshoring firms rises with the minimum wage differential w_E/w_A. Furthermore, the formal condition for only part of European firms engaging in offshoring (i.e., $\chi < 1$) is given by $w_E/w_A < 2^{1/(\sigma-1)} \equiv \bar{\omega}$.

In a next step, we have to determine whether the productivity of the average domestic firm is still equal to the average market productivity with offshoring as in the *pure exporter* scenario. Defining average market productivity $\tilde{\phi}_{it}$ in a way to ensure $P = M_t^{(1-\eta)/(1-\sigma)} p_i(\tilde{\phi}_{it})$, it follows from the respective discussion in Section 4 that $\tilde{\phi}_{it} > \tilde{\phi}_i$. The reason is that with $w_E > w_A$ only the most productive European firms invest and offshore their production to the United States. Hence, there is a positive *selection* effect, which implies that the average productivity in the market is larger than the average productivity of domestic producers. As formally shown in the Appendix, the relationship between $\tilde{\phi}_{it}$ and $\tilde{\phi}_i$ is determined by

$$\tilde{\phi}_{it} = \left[1 + \frac{\chi}{1 + (w_E/w_A)^k}\right]^{\frac{1}{\sigma-1}} \tilde{\phi}_i. \tag{23}$$

From Equations (22) and (23), it follows that $w_E = w_A$ implies $\chi = 0$ and thus, in line with the *pure exporter* scenario, $\tilde{\phi}_{it} = \tilde{\phi}_i$. In contrast, $w_E/w_A \in (1, \bar{\omega})$ yields $\chi \in (0, 1)$ and therefore $\tilde{\phi}_{it} > \tilde{\phi}_i$, which confirms our intuition above. Differentiating the expression in brackets of (23), we can further conclude that the ratio of the average market productivity and the average productivity of domestic firms, $\tilde{\phi}_{it}/\tilde{\phi}_i$, increases monotonically in the cross-country differential of minimum wages, w_E/w_A. Indeed, an increase in the minimum wage differential renders it more attractive for European firms to bear the additional fixed costs of offshoring to the United States. Because offshoring firms need to be more productive than average exporters (in either country) and because these firms can produce at lower costs and thus expand their output after offshoring, the increase of the minimum wage differential raises the productivity differential $\tilde{\phi}_{it}/\tilde{\phi}_i$ in the United States as well as Europe.

With the average market productivity deviating from the average productivity of domestic producers, the modified zero cutoff profit condition for the United States under offshoring is different from the respective condition in the *pure exporter* scenario. We denote the new condition by PMC'_A, which determines again a negative relationship between cutoff productivity ϕ_i^* and firm number M_i as long as $\eta < 1$:

$$\frac{w_i \sigma}{\sigma - 1}\left(\frac{k}{k-\sigma+1}\right)^{\frac{1}{1-\sigma}} \left[1 + \frac{\chi}{1 + (w_E/w_A)^k}\right]^{\frac{1}{1-\sigma}} \frac{1}{\phi_i^*} = \left[\left(1 + \left(\frac{w_i}{w_j}\right)^k\right) M_i\right]^{\frac{1-\eta}{\sigma-1}}, \tag{15'}$$

where $i \neq j$. Comparing Equation (15′) with Equations (7) and (15), we find that the PMC locus shifts southwest in response to an economy's opening up to trade, as in the *pure exporter* scenario. However, with offshoring of production, the respective shift of PMC in Figure 2 is more pronounced and hence the increase in the mass of firms M_i and the decline in productivity levels $\phi_i^*, \tilde{\phi}_i$ is stronger than in the *pure exporter* scenario. The reason is that the gains from trade are higher if European firms can make use of cheaper foreign labor costs through offshoring to the United States. This further stimulates demand for intermediate goods, implying that the open economy is characterized by a larger mass of producers with offshoring than without it. This additional demand stimulus does not rely on the existence of external scale effects. Hence, the PMC-locus in the open economy with offshoring lies below the respective locus of the closed economy, even if $\eta = 1$.

Similar to the *pure exporter* scenario, the surge in firm entry ceteris paribus leads to higher aggregate labor income and to a lower unemployment rate in the two economies. With respect to the U.S. labor market, this effect is reinforced by offshoring of the most productive European firms, so that both aggregate labor income W_A and the employment rate $1 - u_A$ are unambiguously higher in the open than in the closed economy. In Europe, the positive effect of higher firm entry is counteracted by offshoring of European producers with negative implications for domestic employment and aggregate labor income. In general, it is not clear which of the two effects dominates. Hence, with minimum wages being higher in Europe than in the United States, it is possible that European workers are worse off in the open than in the closed economy. European workers would benefit from opening up the economy, if w_E were sufficiently close to w_A. Then, only a small fraction of European producers would be willing to bear the additional investment cost of offshoring to the United States. Conversely, if $w_E/w_A \to \bar{\omega}$, then the share of European nonoffshoring firms would approach zero and, hence, all European workers would become unemployed.

As a final element of our analysis, let us take a closer look at the labor market linkages in an open economy with offshoring. For this purpose, we investigate how an increase in the European minimum wage influences the labor market outcome in the United States. There are two counteracting effects. On the one hand, U.S. workers lose from an external scale effect, if $\eta < 1$. In general, a higher European minimum wage reduces world output and demand, and thus leads to exit of intermediate goods producers in both economies. On the other hand, U.S. workers benefit from a larger share of European firms that shift production across the Atlantic. In the borderline case of $\eta = 1$, only the second effect materializes and, similar to Davis (1998), a higher degree of labor market imperfection in Europe exhibits a positive impact on the U.S. labor market. If, however, $\eta < 1$, this result need not hold any longer. If the external scale effect is sufficiently strong, a negative impact on U.S. workers is possible. In broad terms, we can therefore conclude that offshoring of production lowers the positive correlation between European and U.S. unemployment rates, but it does not (necessarily) destroy it.

7. CONCLUDING REMARKS

This article develops a model of two large economies with heterogeneous intermediate goods producers and imperfect labor markets, due to country-specific real minimum wages. Within this setting, we show that the existence of minimum wages affects the channels through which gains from trade materialize. In the formulation of Melitz and other authors who rely on the assumption of an inelastic labor supply, both an increase in the mass of available varieties and an increase in the cutoff productivity, which improves the composition of firms, are the driving forces behind the welfare gains from trade liberalization. In our model, trade reduces the price index (relative to other prices), quite similar to a model with perfect labor markets. However, with a constant real minimum wage, the price reduction leads to a fall in the nominal wage and thus renders entry of firms with low productivity levels attractive. This worsens the composition of firms and leads to a fall in the cutoff productivity level, an effect which is at odds with Melitz (2003). However, entry of the new firms raises demand for production workers, which contributes to a positive welfare effect due to an increase in aggregate employment at constant real wages.

Under free trade, our model also provides interesting features that differ from the ones of previous work on international labor market linkages in trade models: First, it generates unemployment in all countries despite any differences in the level of minimum wages because, with firm heterogeneity, factor prices do not equalize (even if production is diversified and trade not subject to any impediments) and, second, it motivates a positive correlation of unemployment rates across borders in response to shocks in individual economies. With homogeneous producers and free trade, a minimum wage constraint could only be binding in one country. Consequently, a tightening of the labor market constraint in the country with the higher minimum wage would raise unemployment there and prop up wages abroad as in Davis (1998). However, if firms differ in their productivity, minimum wage constraints may be binding in either country so that positive unemployment is ubiquitous.

With firm heterogeneity, trade only equalizes the production costs of the marginal producers but not of all firms in the international market. In this case, detrimental effects of a tightening of labor market imperfections abroad on world demand will not be offset by a relocation of production from the foreign to the home country, unlike in models with homogeneous producers. Because the contraction of the more constrained economy is moderated by a rise in average productivity of the surviving firms, while the expansion of the less constrained economy is dampened by the entry of firms with lower productivity, the increase in a country's minimum wage exhibits a negative spillover effect on the other country's labor market, thereby inducing a parallel increase in both countries' unemployment rates. This result is remarkable, as it qualifies the by now conventional wisdom among policy makers on both sides of the Atlantic that Europe's reliance on high minimum wages entails an export of jobs and, hence, benefits U.S. workers. Clearly, this effect is important, and the mechanism at work is also present in our model. However, it is more than offset in equilibrium by two additional effects: the reduction in world demand as well as selection of firms into the market according to their productivity. Altogether, our analysis suggests that workers in the United States should be concerned rather than happy about European unemployment.

Of course, the analysis in this article is parsimonious in many regards. For instance, considering minimum wages as the main source of unemployment, although convenient from the perspective of analytical tractability, is quite simplistic from an empirical perspective. Certainly, in reality other labor market institutions than minimum wages may govern positive unemployment rates, and these institutions may differ across countries. Also, our focus on firms that do not face a decision between producing for the local market only versus exporting disregards the fact that only a subsample of a country's producers acts internationally. Although the basic mechanisms at work would unlikely be invalidated by considering more sophisticated reasons of labor market imperfections or by allowing for an extensive margin of exporting (apart from firm entry as such), such modifications may generate additional interesting predictions for empirical work. Finally, it is in principle also possible to extend our model to one with three countries in order to study how third-country shocks are absorbed by the labor markets in the two trading partners. Even though a formal discussion of these effects has not been on our research agenda so far and is clearly beyond the scope of this article, we can hypothesize from our insights above that the costs of such a shock would be partially borne by workers in both countries, as indicated by recent contributions on international labor market linkages.

APPENDIX

A.1. *Derivation of Equation (23).* Our starting point is the price index

$$P = M_t^{\frac{1-\eta}{1-\sigma}} \left[\frac{N}{M_t} \int_{\phi_A^*}^{\infty} p_A(\phi)^{1-\sigma} g(\phi) d\phi + \frac{N}{M_t} \int_{\phi_E^o}^{\infty} p_A(\phi)^{1-\sigma} g(\phi) d\phi + \frac{N}{M_t} \int_{\phi_E^*}^{\phi_E^o} p_E(\phi)^{1-\sigma} g(\phi) d\phi \right]^{\frac{1}{1-\sigma}}. \tag{A.1}$$

Noting $p_E(\phi)/p_A(\phi) = w_E/w_A$ further implies

$$P = M_t^{\frac{1-\eta}{1-\sigma}} p_A(\tilde{\phi}_A) \left[\frac{N}{M_t} \int_{\phi_A^*}^{\infty} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi + \frac{N}{M_t} \int_{\phi_E^o}^{\infty} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi + \frac{N}{M_t} \left(\frac{w_E}{w_A} \right)^{1-\sigma} \int_{\phi_E^*}^{\phi_E^o} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi \right]^{\frac{1}{1-\sigma}}. \tag{A.2}$$

Substituting $p_A(\tilde{\phi}_A) = \left(\tilde{\phi}_{At}/\tilde{\phi}_A\right) p_A(\tilde{\phi}_{At})$, $P = M_t^{(1-\eta)/(1-\sigma)} p_A(\tilde{\phi}_{At})$ and using

$$\tilde{\phi}_i \equiv \left[\frac{N}{M_i} \int_{\phi_i}^{\infty} \phi^{\sigma-1} g(\phi) d\phi \right]^{\frac{1}{\sigma-1}}$$

from the analysis of the closed economy, Equation (A.2) can be rewritten in the following way

$$\tilde{\phi}_{At} = \left[\frac{M_A}{M_t} + \frac{N}{M_t} \int_{\phi_E^o}^{\infty} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi + \frac{N}{M_t} \left(\frac{w_E}{w_A} \right)^{1-\sigma} \int_{\phi_E^*}^{\phi_E^o} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi \right]^{\frac{1}{\sigma-1}} \tilde{\phi}_A. \tag{A.3}$$

We can now consider

$$\frac{N}{M_t} \int_{\phi_E^o}^{\infty} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi = \frac{M_A}{M_t} \left(\frac{\phi_E^o}{\phi_A^*} \right)^{\sigma-1-k},$$

$$\frac{N}{M_t} \left(\frac{w_E}{w_A} \right)^{1-\sigma} \int_{\phi_E^*}^{\phi_E^o} \left(\frac{\phi}{\tilde{\phi}_A} \right)^{\sigma-1} g(\phi) d\phi = \frac{M_E}{M_t} \left[1 - \left(\frac{\phi_E^o}{\phi_E^*} \right)^{\sigma-1-k} \right]$$

to arrive at

$$\begin{aligned} \tilde{\phi}_{At} &= \left\{ \frac{M_A}{M_t} + \frac{M_E}{M_t} \left[1 - \left(\frac{\phi_E^o}{\phi_E^*} \right)^{\sigma-1-k} \right] + \frac{M_A}{M_t} \left(\frac{\phi_E^o}{\phi_A^*} \right)^{\sigma-1-k} \right\}^{\frac{1}{\sigma-1}} \tilde{\phi}_A \\ &= \left[1 - \frac{M_E}{M_t} \left(\frac{\phi_E^o}{\phi_E^*} \right)^{\sigma-1-k} + \frac{M_A}{M_t} \left(\frac{\phi_E^o}{\phi_A^*} \right)^{\sigma-1-k} \right]^{\frac{1}{\sigma-1}} \tilde{\phi}_A. \end{aligned} \tag{A.4}$$

If we make use (16), (22), $\chi = (\phi_E^o/\phi_E^*)^{-k}$, and $M_t = M_E[(w_E/w_A)^k + 1]$, we can reformulate the latter expression to

$$\begin{aligned} \tilde{\phi}_{At} &= \left[1 + \frac{\left[(w_E/w_A)^{\sigma-1} - 1 \right]^{\frac{k}{\sigma-1}}}{(w_E/w_A)^k + 1} \right]^{\frac{1}{\sigma-1}} \tilde{\phi}_A \\ &= \left[1 + \frac{\chi}{(w_E/w_A)^k + 1} \right]^{\frac{1}{\sigma-1}} \tilde{\phi}_A, \end{aligned} \tag{A.5}$$

which confirms the relationship between $\tilde{\phi}_{it}$ and $\tilde{\phi}_i$ in (23) for the United States. Finally, to check whether Equation (23) is a correct description of the relationship between the two averages in Europe, we can account for (16) and substitute $p_E(\tilde{\phi}_E) = p_A(\tilde{\phi}_A)$ in Equation (A.2). Then, following the formal steps from above, we obtain

$$\text{(A.6)} \qquad \tilde{\phi}_{Et} = \left[1 + \frac{\chi}{(w_E/w_A)^k + 1}\right]^{\frac{1}{\sigma-1}} \tilde{\phi}_E,$$

which confirms that (23) is also valid for Europe.

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